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RADIONUCLIDE CONCENTRATIONS IN SOILAROUND WASTE DUMPSITES AND ITS EXCESS LIFETIME CANCER RISK DUE TO GAMMA RADIOACTIVITYIN OGBOMOSO METROPOLIS, SOUTH-WESTERN NIGERIA

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ABSTRACT

Radiation from waste dumpsite as well as certain an tropogenic radionuclides released to the environment are major contribution to terrestrial outdoor exposure. This paper takes a look at the radiation level from twenty major waste dumpsites in Ogbomoso metropolis of Oyo State, Nigeria. Soil samples were taken from 100 locations for laboratory analysis with a very sensitive gamma ray spectroscopy Nal (Tl) scintillation detector. The outdoor gamma dose rates were determined by Alarm Dosimeter Geiger counter portable device and measurements were taken in air for two minutes at 1m from the ground. The outdoor gamma dose rate range from 16.53 to 42.51nGy/h. Annual effective dose rate varied from 0.021 to 0.053mSv/y and the excess lifetime cancer risk within the metropolis range from $0.05x10^{-3}$ to $0.12x10^{-3}$. It was observed that the concentration of radionuclides viz.^{226} R^{234}Th ^{40}K and ^{134} Cs in samples ranges from 7.30 to 35.06Bq/kg, 10.44 to 28.44Bq/kg, 56.42to 1000.42Bq/kg and 7.60Bq/kg, respectively. The soil radio nuclides" concentrations of the study and annual effective gamma dose were within the worldwide range. Excess lifetime cancer risk is far below worldwide rang of $0.29x10^{-3}$ (UNSCEAR, 2000) ^{134}Cs detected was due to fission of heavy radionuclide that may be present in the dump site.

KEYWORDS: Radionuclides, Human Activities

INTRODUCTION

The natural state of different compartments of the environment is perturbed due to human activities. Soil plays host to the reception of direct and by-products of these human activities. The arbitrary and indiscriminate waste dumps in most of our urban area causes high degree of pollution to our environment which is becoming more alarming all around the world because it contaminates both air and water, hence aerobic respiration becomes difficult for living creatures and portable water become scarce for drinking. The threat posed by waste dumps also affects the environmental aesthetic and more importantly the populace is being subjected to various health hazards. Thus, government considers waste management as an essential social service whose budgetary provision is made in line with population projections (Eja et. al, 2010). Hazards posed by such dumpsites are not only in terms of odor and presence of diseases causing microorganism, but can arise from radiation emanating from such dumpsites (Ojoawo et.al 2011).

Radioisotopes that are present in soil significantly affect terrestrial gamma radiation levels. In the last decade, several studies were carried out to assess the average outdoor terrestrial gamma dose rate in air at 1m from the ground. These studies determined that the effective gamma radiation levels were generally in the range of 10-200nGyh^{-1} with a mean of 60nGyh^{-1} (UNSCEAR, 2000).

Various radioactivity measurements have shown the existence of traces of radionuclide in books and in the staple food consumed in Nigeria (Akinloye et. al) All these, are contained in the domestics waste which are indiscriminately

dumped on open fields which may find ways into rivers, well, farmland and boreholes. Measuring terrestrial gamma dose rates is essential since gamma radiation provides information concerning excess lifetime cancer risks. Yet there is no study which evaluate radiation level from waste dumpsite within Ogbomoso metropolis with about one million and two hundred thousand population including students of Ladoke Akintola University of Technology. Hence the objective of this study is to evaluate radio nuclides" radioactivity concentrations as well as environmental outdoor gamma dose rates and excess lifetime cancer risks within the study area.

STUDY AREA

Ogbomoso lies on latitude 8.07N-8.16N and longitude 4.16E-4.30. The population was about 1.2 millon according to 2006 population census.

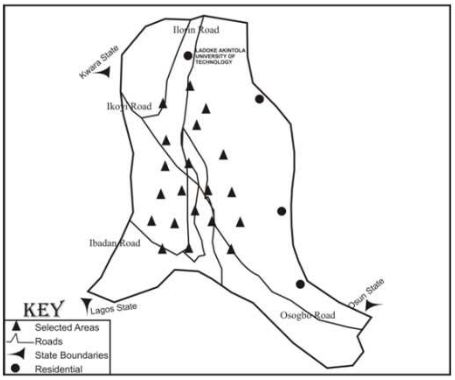

Figure 1: Showing the Sampling Point

MATERIALS AND METHODS

Outdoor gamma dose rate determination

The outdoor gamma dose rates were measured by Radiation Detector Alarm Dosimeter Geiger counter, model LK-3600 with serial numberLK0000001426. Measurements were taken in air for two minutes at 1m above the ground at twenty major dumpsites, for each sampling, measurements were taken at five deferent locations. The mean dose rate of the five measurements were calculated and appointed as the outdoor gamma dose rate of the sampling spots, and the gamma dose rates were recorded in μRh^{-1} and then converted to $nGyh^{-1}$.The gamma absorbed dose in $nGyh^{-1}$ were also converted to annual effective does in $mSvy^{-1}$ as proposed by UNSCEAR (UNSCEAR, 2000).

The Annual Effective Dose Equivalent (AEDE) was calculated by using the following equation.

$$AEDE = ADRA \times DCF \times OF \times T \tag{1}$$

Where ADRA, DCF, OF are Absorbed Dose Rate in Air ($nGyh^{-1}$), Dose Conversion Factor ($0.7SvGy^{-1}$), Outdoor Occupancy factor (0.2), respectively, and T, is the time ($8760\ hy^{-1}$).

Excess Lifetime Cancer Risk (ELCR) was calculated by using equation

$$ELCR = AEDE \times DL \times RF \tag{2}$$

Where DL is Duration of Life (70 years) and RF is Risk Factor (Sv^{-1}), fatal cancer risk per Sievert. For stochastic effects: 1CRP 60 uses values of 0.05 for the public (1CRP, 1990).

DETERMINATION OF SOIL RADIOACTIVITY AND TERRESTRIAL GAMMA DOSE RATES

In order to determine soil radionuclides activity concentration, 20 major dumpsites were selected. Soil samples were taken from 100 locations 20m away from the dumpsite, 5 samples from each location that were close to settlements. Open, flat and undisturbed geographical locations which had good water permeability were selected as the sampling points. The first 10cm of topsoil was taken, foreign bodies were removed and the remaining soil was place in clean, sealed and labeled bags. The samples were dried at 60 ^{0}c for 48 h, grained, passed through 2 mm sieves and placed in Marinelli type beakers. The samples were kept for twenty- eight days before the analysis at airtight condition to allow secular equilibrium between thorium and radium and their decay products. The system was calibrated using standard mixtures of gamma emitting isotopes in Marinelli beakers, traceable to Analytical Quality Control Services (AQCS, U.S.A). Each sample was counted for 36,000s using a gamma spectroscopy device, NaI(Tl) detector. The system is connected to the computerized MCA through a coaxial cable. The activities of the samples were determined using the total net counts under the selected photopeakers, the measured photopeak efficiency, gamma intensity and weight of the samples. After correcting for background and Compton contribution, the activity concentrations of ^{238}U, ^{232}Th, ^{226}Ra, ^{40}K and ^{137}Cs were determined. The ^{238}U and ^{232}Th were calculated assuming secular equilibrium was established with their decay product (^{238}U series: ^{226}Ra, (186.0keV), ^{214}Pd (351.9keV) and ^{214}Bi (609.2keV): ^{232}Th series: ^{228}Ac (911 keV), ^{208}TI (583.1keV))

The concentrations of radionuclides were calculated using the following equation:

$$A = \frac{N_{sam}}{f_E \cdot \eta(E) . T_C . M_{sam}} \tag{3}$$

Where, A is the activity concentrations of the radionuclides in Bq/kg in the samples, M_{sam} is the mass of sample (kg), N_{sam} is the sample net counts in the peak range, f_E is the gamma emission probability, T_C is the counting time and $\eta(E)$ is the photopeak efficiency.

External terrestrial gamma dose rate was calculated from the concentrations of the radionuclides in soil based on the radioactivity levels of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs, gamma Absorbed Dose Rate in Air (ADRA) in nGyh^{-1} at 1 m above the ground level was calculated by using equation (3) (UNSCEAR, 2000).

$$\text{ADRA} = 0.461A_{Ra} + 0.623A_{Th} + 0.0417A_{k} + 0.1243A_{cs} \tag{4}$$

Where A_{Ra}, A_{Th}, A_k and A_{Cs} are activity concentrations (Bq Kg^{-1}) of ^{226}Ra, ^{232} Th, ^{40}K and ^{137}Cs, respectively, in soil sample.

The analyses were carried out in the laboratory of Pure and Applied Physics Department, Radiation and Health Physics Group, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

RESULTS AND DISCUSSIONS

Outdoor gamma dose rates were determined atvarious sampling spots and soil samples taken from the same spots. Table 1 presentsactivity concentration of the samples.

Total outdoor gamma dose rates due to activity present in the samples presented in Table 2 range from 15.313 nGy h^{-1}to 60.997 nGyh^{-1}. Apake, Kara and Oritanira had the highest mean gamma dose rates due to high activity concentration in the two sports.

By using equation (2), excess lifetime cancer risk calculated ranged 0.12 x 10^{-3}to 0.05 x 10^{-3}due to in-situwhen life expectancy was taken as 48years. It was observed that from the table that Apake, Kara and Oritanaira recorded highest

lifetime cancer risk.

The mean ^{238}U, ^{232}Th, ^{134}Cs, and ^{40}K actives for the study were 19.912$\underline{+}$ 0.03 Bq kg^{-1}, 17.675$\underline{+}$ 0.03 Bq kg^{-1}, 40$\underline{+}$18 Bq kg^{-1}, 8 $\underline{+}$ 5Bq kg^{-1}and 79.683$\underline{+}$ 0.03 Bq kg^{-1}, respectively (Table 1).

By using equation (3), the average terrestrial gamma absorbed dose rate in air from relevant radionuclides in soil at 1 m above the ground level calculated ranged between 15.313 to 60.997 nGy h^{-1} (Table 2).

Studies indicate an average outdoor terrestrial gamma dose rate of 60 nGy h^{-1} in the World ranging from 10 to 200 nGy h^{-1} (UNSCEAR, 2000). This study determined that the average terrestrial gamma dose rate of Ogbomoso metropoliswas 118 $\underline{+}$ 34 nGyh^{-1} and higher than the world's average. The level of gamma radiation was directly associated with the activity concentrations of radionuclides in the soil samples and cosmic rays.

Terrestrial gamma dose rates varied considerably within the study area. This variation is associated with the radionuclides' activity concentrations of the soil due to human activities. Within the study area, had the highest outdoor gamma dose rate (60.99 nGyh^{-1}). The same area also had higher ^{40}Kactivity concentrations compared to other parts. This variation is due to differences in materials in the dumpsite assayed.

The long-term exposure to uranium and radium through inhalation has several health effects as chronic lung diseases, acute leucopoenia, anemia and necrosis of the mouth (ATSDR, 1990, 1999). Radium causes bone, cranial, and nasal tumours (ATSDR, 1990, 1992). Thorium exposure can cause lung, pancreas, hepatic, bone, kidney cancers and leukaemia (ATSDR, 1992). Therefore gamma dose rates and radionuclides activity concentrations should be monitored in areas that are rich of radium and uranium.

Excess lifetime cancer risks was calculated, but the health hazard is yet to be evaluated on the population. Since reliable, standardized mortality and morbidity statistics were not accessible, this was limited to background radiation levels.

Table 1: Activity Concentration of^{40} K, ^{226}Raand ^{232}Th (Bq/Kg) Determined for Each of the Measured Samples

S/N	Sample Location		Radonuclides Concentration (Bq/Kg)		
		No of Samples	^{40}K	^{238}U	^{232}Th
1	ADENIKE	5	62.20±0.02	16.50±0.04	19.55±0.02
2	APAKE	5	56.42±0.04	10.66±0.06	19.70±0.01
3	ADUIN	5	97.96±0.01	27.48±0.01	11.12±0.04
4	UNDER G.	5	71.14±.0.02	24.54±0.01	26.36±0.02
5	YOACO	5	71.54 ±0.06	13.00±0.02	10.60±0.01
6	STADIUM	5	75.68±0.05	31.50±0.03	14.40±0.03
7	HIGH COURT	5	68.22±0.02	29.40±0.04	18.55±0.01
8	IGBO-AGBOIN	5	80.53±0.03	16.77±0.02	16.08±0.02
9	IKUYE	5	87.44±0.03	28.45±0.02	16.14±0.01
10	ORITA NAIRA	5	94.16±0.04	12.31±0.01	13.70±0.02
11	TAKIE	5	98.63±0.02	14.14±0.03	23.50±0.05
12	GENERAL	5	84.11±0.03	23.04±0.01	13.14±0.02
13	ISALE GENERAL	5	60.63±0.03	15.50±0.02	12.80±0.04
14	SABO	5	85.91±0.01	13.40±0.05	28.44±0.03
15	KARA	5	97.98±0.04	15.12±0.03	24.44±0.01
16	OKE-ADO	5	64.36±0.01	35.06±0.01	18.92±0.01
17	MARYLAND	5	100.02±0.02	14.30±0.04	21.01±0.03
18	OKE-AANU	5	79.32±0.03	22.33±0.02	10.44±0.02
19	WAZO MARKET	5	96.31±0.05	27.44±0.04	19.06±0.03
20	OSUPA	5	61.10±0.02	7.30±0.05	15.55±0.04
	Average		**79.683±0.03**	**19.912±0.05**	**17.675±0.03**

Table 2: Outdoor Gammas Does Rate, Annual Effective Dose Equivalent and the Excess Lifetime Risks of Cancer, Due to Activity Present in the Samples

S/N	Sample Location	Absorbed Dose Rate (Ngyh^{-1})	Annual Effective Dose Equivalent (Msvy^{-1})	Excess Lifetime Cancer Risk (Elcr)
1	ADENIKE	22.024	0.027	0.0648X10-3
2	APAKE	19.176	0.024	0.0576X10-3
3	ADUIN	23.497	0.028	0.0672X10-3
4	UNDER G.	30.225	0.037	0.0888X10-3
5	YOACO	15.391	0.019	0.0456X10-3
6	STADIUM	26.406	0.0324	0.0778X10-3
7	HIGH COURT	27.632	0.0339	0.0814X10-3
8	IGBO-AGBON	20.818	0.0255	0.0612X10-3
9	IKUYE	26.539	0.0325	0.078X10-3
10	ORITA NAIRA	17.888	0.0219	0.0526X10-3
11	TAKIE	24.839	0.0305	0.0732X10-3
12	GENERAL	22.088	0.0274	0.0658X10-3
13	ISALE GENERAL	17.420	0.0214	0.0514X10-3
14	SABO	26.951	0.0331	0.0794X10-3
15	KARA	25.833	0.0317	0.0761X10-3
16	OKE-ADO	30.309	0.0372	0.0893X10-3
17	MARYLAND	60.997	0.0748	0.175X10-3
18	OKE-AANU	19.925	0.0244	0.0586X10-3
19	WAZO MARKET	28.206	0.0346	0.0883X10-3
20	OSUPA	15.313	0.0188	0.0451X10-3

Table 3: Absorb Dose Rate, Annual Effective Dose Equivalent and Excess Lifetime Cancer Risk Due to In-Situ

S/N	Sample Location	Absorbed Dose Rate (Ngyh^{-1})	Annual Effective Dose Equivalent (Msvy^{-1})	Excess Lifetime Cancer Risk (Elcr)
1	ADENIKE	19.84	0.025	0.06×10^{-3}
2	APAKE	42.51	0.053	0.12×10^{-3}
3	ADUIN	31.85	0.039	0.09×10^{-3}
4	UNDER G.	27.78	0.033	0.08×10^{-3}
5	YOACO	29.41	0.037	0.08×10^{-3}
6	STADIUM	18.95	0.024	0.05×10^{-3}
7	HIGH COURT	25.83	0.032	0.08×10^{-3}
8	IGBO-AGBON	22.50	0.028	0.07×10^{-3}
9	IKUYE	26.31	0.033	0.07×10^{-3}
10	ORITA NAIRA	35.85	0.044	0.12×10^{-3}
11	TAKIE	28.01	0.034	0.08×10^{-3}
12	GENERAL	17.33	0.022	0.05×10^{-3}
13	ISALE GENERAL	25.42	0.031	0.07×10^{-3}
14	SABO	21..24	0.027	0.06×10^{-3}
15	KARA	34.74	0.043	0.11×10^{-3}
16	OKE-ADO	21.66	0.027	0.07×10^{-3}
17	MARYLAND	22.72	0.028	0.07×10^{-3}
18	OKE-AANU	16.53	0.021	0.05×10^{-3}
19	WAZO MARKET	24.26	0.030	0.07×10^{-3}
20	OSUPA	32.25	0.040	0.10×10^{-3}

CONCLUSIONS

It is important to determine background radiation level in order to evaluate the health hazards. This study determined that the average soil activity concentrations, absorbed dose rate, annual effectivedose rate and lifetime cancer risk of Ogbomoso metropolis were within the worldwide range for both in-situ and calculated measurement.

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